What is claimed is:

1. A method of producing hydrogen comprising:

conducting a reaction between a hydride composition and a hydroxide composition to form hydrogen and an oxide composition, wherein said hydroxide composition has one or more cationic species other than hydrogen.

2. The method according to claim 1 wherein said hydride composition has one or more cationic species other than hydrogen.

3. The method according to claim 2 wherein said oxide composition comprises at least one of said one or more cations other than hydrogen derived from either of said hydride or said hydroxide compositions, respectively.

4. The method according to claim 1 wherein said hydride composition is represented by the formula: $MI^{x}H_{x}$, where MI represents said one or more cationic species other than hydrogen and x represents an average valence state of MI.

5. The method according to claim 1 wherein said hydroxide composition is represented by the formula: $MII^{y}(OH)_{y}$, where MII represents said one or more cationic species other than hydrogen and y represents an average valence state of MII.

6. The method according to claim 1 wherein said hydroxide composition is represented by the formula: $MII^{y}(OH)_{y}\cdot wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

7. The method of claim 1 wherein said hydride composition is represented by $MI^{x}H_{x}$ and said hydroxide composition is represented by $MII^{y}(OH)_{y}$, where MI and MII respectively represent one or more cationic species other than hydrogen, and x and y represent average valence states of MI and MII, respectively.

8. The method of claim 7 wherein MI and MII are different cationic species.

9. The method of claim 7 wherein MI and MII are the same cationic species.

10. The method of claim 7 wherein MI is a complex cationic species comprising two distinct cationic species.

11. The method of claim 7 wherein MII is a complex cationic species comprising two distinct cationic species.

12. The method of claim 7 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

13. The method of claim 7 wherein MII is selected from the group consisting of CH_3, C_2H_5, C_3H_7, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

14. The method of claim 13 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

15. The method of claim 14 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

16. The method of claim 7 wherein said hydroxide composition further comprises: $MII^{y}(OH)_{y} \cdot wH_2O$, where MII represents said one or more cationic

species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

17. The method of claim 16 wherein said oxide composition is a complex oxide.

18. The method of claim 1 wherein said hydride composition is represented by MI^xH_x and said hydroxide composition is represented by $MII^y(OH)_y{\cdot}wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

19. The method of claim 18 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

20. The method of claim 19 wherein MII is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

21. The method of claim 20 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

22. The method of claim 21 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

23. The method according to claim 1 wherein said hydroxide composition comprises an organic group.

24. The method according to claim 1 wherein said hydride composition is selected from the group consisting of: lithium hydride (LiH), sodium hydride (NaH), potassium hydride (KH), beryllium hydride (BeH_2), magnesium hydride (MgH_2), calcium hydride (CaH_2), strontium hydride (SrH_2), titanium hydride (TiH_2), aluminum hydride (AlH_3), boron hydride (BH_3), lithium borohydride ($LiBH_4$), sodium borohydride ($NaBH_4$), magnesium borohydride ($Mg(BH_4)_2$), calcium borohydride ($Ca(BH_4)_2$), lithium alanate ($LiAlH_4$), sodium alanate ($NaAlH_4$), magnesium alanate ($Mg(AlH_4)_2$), calcium alanate ($Ca(AlH_4)_2$), and mixtures thereof.

25. The method according to claim 1 wherein said hydroxide composition is selected from the group consisting of: lithium hydroxide (LiOH),

sodium hydroxide (NaOH), potassium hydroxide (KOH), beryllium hydroxide ($Be(OH)_2$), magnesium hydroxide ($Mg(OH)_2$), calcium hydroxide ($Ca(OH)_2$), strontium hydroxide ($Sr(OH)_2$), titanium hydroxide ($Ti(OH)_2$), aluminum hydroxide ($Al(OH)_3$), boron hydroxide ($B(OH)_3$) and mixtures thereof.

26. The method according to claim 1 wherein said hydroxide composition is selected from the group consisting of: hydrated lithium hydroxide ($LiOH \cdot H_2O$), hydrated sodium hydroxide ($NaOH \cdot H_2O$), hydrated potassium hydroxide ($KOH \cdot H_2O$), hydrated barium hydroxide ($Ba(OH)_2 \cdot 3H_2O$), hydrated barium hydroxide ($Ba(OH)_2 \cdot H_2O$), hydrated lithium aluminum hydroxide ($LiAl_2(OH)_7 \cdot 2H_2O$), hydrated magnesium aluminum hydride ($Mg_6Al_2(OH)_{18} \cdot 4H_2O$), and mixtures thereof.

27. The method according to claim 1 wherein said hydride composition comprises LiH and said hydroxide composition comprises LiOH.

28. The method according to claim 27 wherein said reaction proceeds according to a reaction mechanism of $LiH + LiOH \rightarrow Li_2O + H_2$.

29. The method according to claim 1 wherein said hydride composition comprises NaH and said hydroxide composition comprises LiOH.

30. The method according to claim 29 wherein said reaction proceeds according to a reaction mechanism of $NaH + LiOH \rightarrow \frac{1}{2} Li_2O + \frac{1}{2} Na_2O + H_2$.

31. The method according to claim 1 wherein said hydride composition comprises MgH_2 and said hydroxide composition comprises $Mg(OH)_2$.

32. The method according to claim 31 wherein said reaction proceeds according to a reaction mechanism of $MgH_2 + Mg(OH)_2 \rightarrow MgO + 2 H_2$.

33. The method according to claim 1 wherein said hydride composition comprises AlH_3 and said hydroxide composition comprises $Al(OH)_3$.

34. The method according to claim 33 wherein said reaction proceeds according to a reaction mechanism of $AlH_3 + Al(OH)_3 \rightarrow Al_2O_3 + 3H_2$.

35. The method according to claim 1 wherein said hydride composition comprises CaH_2 and said hydroxide composition comprises $Ca(OH)_2$.

36. The method according to claim 35 wherein said reaction proceeds according to a reaction mechanism of $CaH_2 + Ca(OH)_2 \rightarrow CaO + 2 H_2$.

37. The method according to claim 1 wherein said hydride composition comprises SrH_2 and said hydroxide composition comprises $Sr(OH)_2$.

38. The method according to claim 37 wherein said reaction proceeds according to a reaction mechanism of $SrH_2 + Sr(OH)_2 \rightarrow SrO + 2\ H_2$.

39. The method according to claim 1 wherein said hydride composition comprises BH_3 and said hydroxide composition comprises $B(OH)_3$.

40. The method according to claim 39 wherein said reaction proceeds according to a reaction mechanism of $BH_3 + B(OH)_3 \rightarrow B_2O_3 + 3\ H_2$.

41. The method according to claim 1 wherein said hydride composition comprises BeH_2 and said hydroxide composition comprises $Be(OH)_2$.

42. The method according to claim 41 wherein said reaction proceeds according to a reaction mechanism of $BeH_2 + Be(OH)_2 \rightarrow BeO + 2\ H_2$.

43. The method according to claim 1 where said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises $B(OH)_3$.

44. The method according to Claim 43 where said reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow LiBO_2 + Li_2O + 3H_2$.

45. The method according to Claim 43 where said reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow Li_3BO_3 + 3H_2$.

46. The method according to Claim 43 where said reaction proceeds according to a reaction mechanism of $3\ LiBH_4 + 4\ H_3BO_3 \rightarrow Li_3B_7O_{12} + 12\ H_2$.

47. The method according to claim 1 where said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises LiOH.

48. The method according to Claim 47 where said reaction proceeds according to a reaction mechanism of $LiBH_4 + 4\ LiOH \rightarrow LiBO_2 + 2\ Li_2O + 4H_2$

49. The method according to claim 1 where said hydride composition comprises $NaBH_4$ and said hydroxide composition comprises $Mg(OH)_2$.

50. The method according to Claim 49 where said reaction proceeds according to a reaction mechanism of $NaBH_4 + 2\ Mg(OH)_2 \rightarrow NaBO_2 + 2MgO + 4H_2$

51. The method according to claim 1 where said hydride composition comprises $NaBH_4$ and said hydroxide composition comprises NaOH.

52. The method according to Claim 51 where said reaction proceeds according to a reaction mechanism of $NaBH_4 + 4NaOH \rightarrow NaBO_2 + 2Na_2O + 4H_2$.

53. The method according to claim 1 where said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises LiOH and $LiOH \cdot H_2O$.

54. The method according to Claim 53 where said reaction proceeds according to a reaction mechanism of $LiBH_4 + LiOH + LiOH \cdot H_2O \rightarrow Li_3BO_3 + 2\ Li_2O + 4H_2$.

55. The method according to Claim 53 where said reaction proceeds according to a reaction mechanism of $2\ LiBH_4 + LiOH + 2\ LiOH \cdot H_2O \rightarrow Li_4B_2O_5 + LiH + 7\ H_2$.

56. The method according to claim 1 wherein said hydride composition comprises MgH_2 and said hydroxide composition comprises $LiOH \cdot H_2O$.

57. The method according to claim 56 wherein said reaction proceeds according to a reaction mechanism of $3MgH_2 + 2LiOH \cdot H_2O \rightarrow 3MgO + Li_2O + 6H_2$.

58. The method according to claim 1 wherein said hydride composition comprises LiH and said hydroxide composition comprises $LiOH \cdot H_2O$.

59. The method according to claim 58 wherein said reaction proceeds according to a reaction mechanism of $3LiH + LiOH{\cdot}H_2O \rightarrow 2Li_2O + 3H_2$.

60. The method according to claim 1 wherein said hydride composition comprises NaH and said hydroxide composition comprises $LiOH{\cdot}H_2O$.

61. The method according to claim 60 wherein said reaction proceeds according to a reaction mechanism of $6NaH + 2LiOH{\cdot}H_2O \rightarrow 3Na_2O + Li_2O + 6H_2$.

62. The method according to claim 1 wherein said hydride composition comprises LiH and said hydroxide composition comprises $NaOH{\cdot}H_2O$.

63. The method according to claim 62 wherein said reaction proceeds according to a reaction mechanism of $6LiH + 2NaOH{\cdot}H_2O \rightarrow 3Li_2O + Na_2O + 6H_2$.

64. The method according to claim 1 wherein said hydride composition comprises NaH and said hydroxide composition comprises $NaOH{\cdot}H_2O$.

65. The method according to claim 64 wherein said reaction proceeds according to a reaction mechanism of $3NaH + NaOH{\cdot}H_2O \rightarrow 2Na_2O + 3H_2$.

66. The method according to claim 1 wherein said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises $LiOH \cdot H_2O$.

67. The method according to claim 66 wherein said reaction proceeds according to a reaction mechanism of $3LiBH_4 + 4LiOH \cdot H_2O \rightarrow 3LiBO_2 + 2Li_2O + 12H_2$.

68. The method according to claim 1 wherein said hydride composition comprises $NaBH_4$ and said hydroxide composition comprises $NaOH \cdot H_2O$.

69. The method according to claim 68 wherein said reaction proceeds according to a reaction mechanism of $3NaBH_4 + 4NaOH \cdot H_2O \rightarrow 3NaBO_2 + 2Na_2O + 12H_2$.

70. The method according to claim 1 wherein said reaction is reversible to form a species of said hydride composition or said hydroxide composition.

71. The method according to claim 70 wherein said reversible reaction is conducted by exposing said oxide composition to hydrogen to form said species.

72. The method according to claim 71 wherein said reversible reaction regenerates said hydride composition and said hydroxide composition.

73. The method according to claim 1 wherein said reaction is conducted at an elevated temperature relative to ambient conditions.

74. The method according to claim 73 wherein said reaction is conducted at a temperature 40° C or greater.

75. The method according to claim 1 wherein said hydride composition and said hydroxide composition are in particle form and said reaction is a solid-state reaction.

76. The method according to claim 75 wherein said hydride composition and said hydroxide composition are reduced in particle size prior to said reaction.

77. The method according to claim 1 wherein before conducting said reaction, said hydride composition and said hydroxide composition are essentially homogeneously mixed together.

78. The method according to claim 1 wherein during said reaction, said oxide composition, said hydrogen, or both, are removed from said hydride composition and said hydroxide composition, as said reaction proceeds.

79. The method according to claim 1 wherein during said reaction said hydrogen is a removed as said reaction proceeds.

80. The method according to claim 1 wherein said reaction is conducted in the presence of a catalyst in contact with said hydride composition and said hydroxide composition.

81. The method according to claim 80 wherein said catalyst comprises a compound comprising an element selected from the group consisting of Ti, V, Cr, C, Fe, Mn, Ni, Nb, Pd, Si, Al, and mixtures thereof.

82. A method for releasing hydrogen from hydrogen storage materials comprising:

mixing a first hydrogen storage material with a second hydrogen storage material, where said first hydrogen storage material comprises a hydride composition represented by MI^xH_x and said second hydrogen storage material comprises a hydroxide composition represented by $MII^y(OH)_y$, where MI and MII each represent a cationic species or a mixture of cationic species other than hydrogen, and where x and y represent average valence states of respectively MI and MII; and

conducting a reaction between said first storage material with said second storage material for a time and at a temperature sufficient to produce a reaction product comprising an oxide material and hydrogen.

83. The method of claim 82 wherein MI and MII are different cationic species.

84. The method of claim 82 wherein MI and MII are the same cationic species.

85. The method of claim 82 wherein MI is a complex cationic species comprising two distinct cationic species.

86. The method of claim 82 wherein MII is a complex cationic species comprising two distinct cationic species.

87. The method of claim 82 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

88. The method of claim 82 wherein MII is selected from the group consisting of CH_3, C_2H_5, C_3H_7, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

89. The method of claim 88 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

90. The method of claim 89 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

91. The method according to claim 82 wherein said hydroxide composition comprises an organic group.

92. The method according to claim 82 wherein said hydride composition is selected from the group consisting of: lithium hydride (LiH), sodium hydride (NaH), potassium hydride (KH), beryllium hydride (BeH_2), magnesium hydride (MgH_2), calcium hydride (CaH_2), strontium hydride (SrH_2), titanium hydride (TiH_2), aluminum hydride (AlH_3), boron hydride (BH_3), lithium borohydride ($LiBH_4$), sodium borohydride ($NaBH_4$), magnesium borohydride ($Mg(BH_4)_2$), calcium borohydride ($Ca(BH_4)_2$), lithium alanate ($LiAlH_4$), sodium alanate ($NaAlH_4$), magnesium alanate ($Mg(AlH_4)_2$), calcium alanate ($Ca(AlH_4)_2$), and mixtures thereof.

93. The method according to claim 82 wherein said hydroxide composition is selected from the group consisting of: lithium hydroxide (LiOH), sodium hydroxide (NaOH), potassium hydroxide (KOH), beryllium hydroxide ($Be(OH)_2$), magnesium hydroxide ($Mg(OH)_2$), calcium hydroxide ($Ca(OH)_2$), strontium hydroxide ($Sr(OH)_2$), titanium hydroxide ($Ti(OH)_2$), aluminum hydroxide ($Al(OH)_3$), boron hydroxide ($B(OH)_3$) and mixtures thereof.

94. The method according to claim 82 wherein said hydride composition comprises LiH and said hydroxide composition comprises LiOH.

95. The method according to claim 94 wherein said reaction proceeds according to a reaction mechanism of $LiH + LiOH \rightarrow Li_2O + H_2$.

96. The method according to claim 82 wherein said hydride composition comprises NaH and said hydroxide composition comprises LiOH.

97. The method according to claim 96 wherein said reaction proceeds according to a reaction mechanism of $NaH + LiOH \rightarrow \frac{1}{2} Li_2O + \frac{1}{2} Na_2O + H_2$.

98 . The method according to claim 82 wherein said second hydrogen storage material further comprises a second hydroxide composition represented by $MII^{y}(OH)_y{\cdot}wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

99. The method according to claim 98 wherein said hydroxide composition is selected from the group consisting of: hydrated lithium hydroxide ($LiOH{\cdot}H_2O$), hydrated sodium hydroxide ($NaOH{\cdot}H_2O$), hydrated potassium hydroxide ($KOH{\cdot}H_2O$), hydrated barium hydroxide ($Ba(OH)_2{\cdot}3H_2O$), hydrated barium hydroxide ($Ba(OH)_2{\cdot}H_2O$), hydrated lithium aluminum hydroxide ($LiAl_2(OH)_7{\cdot}2H_2O$), hydrated magnesium aluminum hydride ($Mg_6Al_2(OH)_{18}{\cdot}4H_2O$), and mixtures thereof.

100. The method according to claim 82 wherein said reaction is reversed by exposing said oxide material to hydrogen to form a regenerated first storage

material comprising a hydride and a regenerated second storage material comprising a hydroxide.

101. The method according to claim 100 wherein said hydride of said regenerated first storage material and said hydroxide of said regenerated second storage material are the same species as said first and said second starting materials, comprising said hydride and said hydroxide, respectively.

102. The method according to claim 82 wherein said reaction is conducted at an elevated temperature relative to ambient conditions.

103. The method according to claim 102 wherein said reaction is conducted at a temperature of 40° C or greater.

104. The method according to claim 82 wherein said first starting material and said second starting material are in particle form and said reaction is a solid state reaction.

105. The method according to claim 104 wherein said first starting material and said second starting material are reduced in particle size prior to said reaction.

106. The method according to claim 82 wherein before conducting said reaction, said first starting material and said second starting material are essentially homogeneously mixed together.

107. The method according to claim 82 wherein during said reaction, said oxide, said hydrogen, or both, are removed from said first starting material and said second starting material, as said reaction proceeds.

108. The method according to claim 82 wherein during said reaction said hydrogen is a removed from said first and said second starting materials as said reaction proceeds.

109. The method according to claim 82 wherein said reaction is conducted in the presence of a catalyst in contact with said first starting material and said second starting material.

110. The method according to claim 109 wherein said catalyst comprises a compound comprising an element selected from the group consisting of Ti, V, Cr, C, Fe, Mn, Ni, Nb, Pd, Si, Al, and mixtures thereof.

111. A hydrogen storage composition having a hydrogenated state and a dehydrogenated state:

(a) in said hydrogenated state, said composition comprises a hydride and a hydroxide having one or more cationic species other than hydrogen; and

(b) in said dehydrogenated state, said composition comprises an oxide.

112. The composition of claim 111 wherein said hydride is represented by the formula MI^xH_x, where MI represents one or more cationic species other than hydrogen, and x is an average valence state of MI.

113. The composition of claim 111 wherein said hydroxide is represented by the formula $MII^y(OH)_y$, where MII represents one or more cationic species other than hydrogen, and y is an average valence state of MII.

114. The composition of claim 111 wherein said hydroxide is represented by the formula $MII^y(OH)_y \cdot wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

115. The composition of claim 111 wherein said hydroxide comprises a first hydroxide having the formula $MII^y(OH)_y$ and a second hydroxide compound

having the formula , $MII^{y}(OH)_{y}{\cdot}wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

116. The composition of claim 115 wherein said oxide comprises a complex higher-order oxide.

117. The composition of claim 111 wherein said hydride is represented by $MI^{x}H_{x}$ and said hydroxide is represented by $MII^{y}(OH)_{y}$, where MI and MII respectively represent one or more cationic species other than hydrogen, and x and y represent average valence states of MI and MII, respectively.

118. The composition of claim 117 wherein MI and MII are different cationic species.

119. The composition of claim 117 wherein MI is a complex cationic species comprising two distinct cationic species.

120. The composition of claim 117 wherein MII is a complex cationic species comprising two distinct cationic species.

121. The composition of claim 117 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg,

In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

122. The composition of claim 117 wherein MII is selected from the group consisting of CH_3, C_2H_5, C_3H_7, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

123. The composition of claim 122 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

124. The composition of claim 123 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

125. The composition of claim 111 wherein said hydride is represented by MI^xH_x and said hydroxide is represented by $MII^y(OH)_y \cdot wH_2O$, where MI and MII respectively represent one or more cationic species other than hydrogen, x and y represent average valence states of MI and MII, respectively and w represents a stoichiometric amount of hydrated water.

126. The composition of claim 125 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

127. The composition of claim 126 wherein MII is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

128. The composition of claim 127 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

129. The composition of claim 128 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

130. The composition of claim 111 wherein said hydroxide comprises an organic group.

131. The composition of claim 111 wherein said hydride is selected from the group consisting of: lithium hydride (LiH), sodium hydride (NaH), potassium

hydride (KH), beryllium hydride (BeH_2), magnesium hydride (MgH_2), calcium hydride (CaH_2), strontium hydride (SrH_2), titanium hydride (TiH_2), aluminum hydride (AlH_3), boron hydride (BH_3), lithium borohydride ($LiBH_4$), sodium borohydride ($NaBH_4$), magnesium borohydride ($Mg(BH_4)_2$), calcium borohydride ($Ca(BH_4)_2$), lithium alanate ($LiAlH_4$), sodium alanate ($NaAlH_4$), magnesium alanate ($Mg(AlH_4)_2$), calcium alanate ($Ca(AlH_4)_2$), and mixtures thereof.

132. The composition of claim 111 wherein said hydroxide is selected from the group consisting of: lithium hydroxide (LiOH), sodium hydroxide (NaOH), potassium hydroxide (KOH), beryllium hydroxide ($Be(OH)_2$), magnesium hydroxide ($Mg(OH)_2$), calcium hydroxide ($Ca(OH)_2$), strontium hydroxide ($Sr(OH)_2$), titanium hydroxide ($Ti(OH)_2$), aluminum hydroxide ($Al(OH)_3$), boron hydroxide ($B(OH)_3$) and mixtures thereof.

133. The composition of claim 111 wherein said hydride comprises LiH.

134. The composition of claim 111 wherein said hydroxide comprises LiOH.

135. The composition of claim 111 wherein said hydride composition comprises LiH and said hydroxide composition comprises LiOH.

136. The composition of claim 135 wherein said reaction proceeds according to a reaction mechanism of $LiH + LiOH \rightarrow Li_2O + H_2$.

137. The composition of claim 111 wherein said hydride composition comprises NaH and said hydroxide composition comprises LiOH.

138. The composition of claim 137 wherein said reaction proceeds according to a reaction mechanism of $NaH + LiOH \rightarrow \frac{1}{2} Li_2O + \frac{1}{2} Na_2O + H_2$.

139. The composition according to claim 111 wherein said hydride composition comprises MgH_2 and said hydroxide composition comprises $Mg(OH)_2$.

140. The composition according to claim 139 wherein said reaction proceeds according to a reaction mechanism of $MgH_2 + Mg(OH)_2 \rightarrow MgO + 2\ H_2$.

141. The composition according to claim 111 wherein said hydride composition comprises AlH_3 and said hydroxide composition comprises $Al(OH)_3$.

142. The composition according to claim 141 wherein said reaction proceeds according to a reaction mechanism of $AlH_3 + Al(OH)_3 \rightarrow Al_2O_3 + 3H_2$.

143. The composition according to claim 111 wherein said hydride composition comprises CaH_2 and said hydroxide composition comprises $Ca(OH)_2$.

144. The composition according to claim 143 wherein said reaction proceeds according to a reaction mechanism of $CaH_2 + Ca(OH)_2 \rightarrow CaO + 2\ H_2$.

145. The composition according to claim 111 wherein said hydride composition comprises SrH_2 and said hydroxide composition comprises $Sr(OH)_2$.

146. The composition according to claim 145 wherein said reaction proceeds according to a reaction mechanism of $SrH_2 + Sr(OH)_2 \rightarrow SrO + 2\ H_2$.

147. The composition according to claim 111 wherein said hydride composition comprises BH_3 and said hydroxide composition comprises $B(OH)_3$.

148. The composition according to claim 147 wherein said reaction proceeds according to a reaction mechanism of $BH_3 + B(OH)_3 \rightarrow B_2O_3 + 3\ H_2$.

149. The composition according to claim 111 wherein said hydride composition comprises BeH_2 and said hydroxide composition comprises $Be(OH)_2$.

150. The composition according to claim 149 wherein said reaction proceeds according to a reaction mechanism of $BeH_2 + Be(OH)_2 \rightarrow BeO + 2\ H_2$.

151. The composition according to claim 111 where said hydride composition comprises $LiBH_4$ and said hydroxide comprises $B(OH)_3$.

152. The composition according to claim 151 where said reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow LiBO_2 + Li_2O + 3H_2$.

153. The composition according to claim 151 where said reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow Li_3BO_3 + 3H_2$.

154. The composition according to claim 151 where said reaction proceeds according to a reaction mechanism of $3\ LiBH_4 + 4\ H_3BO_3 \rightarrow Li_3B_7O_{12} + 12\ H_2$.

155. The composition according to claim 111 where said hydride composition comprises $LiBH_4$ and said hydroxide comprises LiOH.

156. The composition according to claim 155 where said reaction proceeds according to a reaction mechanism of $LiBH_4 + 4\ LiOH \rightarrow LiBO_2 + 2\ Li_2O + 4H_2$

157. The composition according to claim 111 where said hydride composition comprises $NaBH_4$ and said hydroxide comprises $Mg(OH)_2$.

158. The composition according to claim 157 where said reaction proceeds according to a reaction mechanism of $NaBH_4 + 2\ Mg(OH)_2 \rightarrow NaBO_2 + 2MgO + 4H_2$

. 159 . The composition according to claim 111 where said hydride composition comprises $NaBH_4$ and said hydroxide comprises NaOH.

160. The composition according to claim 159 where said reaction proceeds according to a reaction mechanism of $NaBH_4 + 4\ NaOH \rightarrow NaBO_2 + 2\ Na_2O + 4\ H_2$.

161. The composition according to claim 111 where said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises LiOH and $LiOH \cdot H_2O$.

162. The composition according to claim 161 where said reaction proceeds according to a reaction mechanism of $LiBH_4 + LiOH + LiOH \cdot H_2O \rightarrow Li_3BO_3 + 2\ Li_2O + 4H_2$.

163. The composition according to claim 161 where said reaction proceeds according to a reaction mechanism of 2 $LiBH_4$ + LiOH + 2 $LiOH{\cdot}H_2O \rightarrow Li_4B_2O_5$ + LiH + 7 H_2.

164. The composition according to claim 111 wherein said hydride composition comprises MgH_2 and said hydroxide composition comprises $LiOH{\cdot}H_2O$.

165. The composition according to claim 164 wherein said reaction proceeds according to a reaction mechanism of $3MgH_2 + 2LiOH{\cdot}H_2O \rightarrow 3MgO + Li_2O + 6H_2$.

166. The composition according to claim 111 wherein said hydride composition comprises LiH and said hydroxide composition comprises $LiOH{\cdot}H_2O$.

167. The composition according to claim 166 wherein said reaction proceeds according to a reaction mechanism of $3LiH + LiOH{\cdot}H_2O \rightarrow 2Li_2O + 3H_2$.

168. The composition according to claim 111 wherein said hydride composition comprises NaH and said hydroxide composition comprises $LiOH{\cdot}H_2O$.

169. The composition according to claim 168 wherein said reaction proceeds according to a reaction mechanism of $6NaH + 2LiOH{\cdot}H_2O \rightarrow 3Na_2O + Li_2O + 6H_2$.

170. The composition according to claim 111 wherein said hydride composition comprises LiH and said hydroxide composition comprises $NaOH{\cdot}H_2O$.

171. The composition according to claim 170 wherein said reaction proceeds according to a reaction mechanism of $6LiH + 2NaOH{\cdot}H_2O \rightarrow 3Li_2O + Na_2O + 6H_2$.

172. The composition according to claim 111 wherein said hydride composition comprises NaH and said hydroxide composition comprises $NaOH{\cdot}H_2O$.

173. The composition according to claim 172 wherein said reaction proceeds according to a reaction mechanism of $3NaH + NaOH{\cdot}H_2O \rightarrow 2Na_2O + 3H_2$.

174. The composition according to claim 111 wherein said hydride composition comprises $LiBH_4$ and said hydroxide composition comprises $LiOH{\cdot}H_2O$.

175. The composition according to claim 174 wherein said reaction proceeds according to a reaction mechanism of $3LiBH_4 + 4LiOH{\cdot}H_2O \rightarrow 3LiBO_2 + 2Li_2O + 12H_2$.

176. The composition according to claim 111 wherein said hydride composition comprises $NaBH_4$ and said hydroxide composition comprises $NaOH{\cdot}H_2O$.

177. The composition according to claim 176 wherein said reaction proceeds according to a reaction mechanism of $3NaBH_4 + 4NaOH{\cdot}H_2O \rightarrow 3NaBO_2 + 2Na_2O + 12H_2$.

178. A method of producing a source of hydrogen gas comprising:

liberating hydrogen from a solid hydrogenated starting material composition comprising a hydride and a hydroxide, by reacting said hydride and said hydroxide in a solid state reaction to produce a dehydrogenated reaction product and hydrogen gas.

179. The method according to claim 178 wherein said hydride and said hydroxide each have one or more cationic species other than hydrogen.

180. The method according to claim 178 further comprising regenerating said hydrogenated starting material composition by exposing said dehydrogenated product to hydrogen gas.

181. The method of claim 178 wherein said dehydrogenated product comprises an oxide.

182. The method of claim 178 wherein said regenerating is conducted at an elevated temperature relative to ambient conditions.

183. The method of claim 182 wherein said liberating of hydrogen is conducted at an elevated temperature greater than about 40°C.

184. The method of claim 178 wherein said liberating is conducted by removing said hydrogen gas as said reacting proceeds.

185. The method of claim 178 wherein said liberating is conducted in the presence of a catalyst in contact with said starting material composition.

186. The method according to claim 185 wherein said catalyst comprises a compound comprising an element selected from the group consisting of Ti, V, Cr, C, Fe, Mn, Ni, Nb, Pd, Si, Al, and mixtures thereof.

187. A mixture of a hydride and a hydroxide having cationic species other than hydrogen, each one characterized by promoting release of hydrogen from the other one in the presence of: a catalyst, elevated temperature, or both.

188. The mixture of claim 187 further characterized in that the release of hydrogen results in formation of an oxide.

189. The mixture of claim 187 wherein said hydride is represented by the formula MI^xH_x, where MI represents one or more cationic species other than hydrogen, and x is an average valence state of MI.

190. The mixture of claim 187 wherein said hydroxide is represented by the formula $MII^y(OH)_y$, where MII represents one or more cationic species other than hydrogen, and y is an average valence state of MII.

191. The mixture of claim 187 wherein said hydroxide is represented by the formula $MII^y(OH)_y{\cdot}wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

192. The mixture of claim 187 wherein said hydroxide comprises a first hydroxide compound having the formula $MII^y(OH)_y$ and a second hydroxide compound having the formula , $MII^y(OH)_y{\cdot}wH_2O$, where MII represents said one

or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

193. The mixture of claim 187 wherein said hydride is represented by MI^xH_x and said hydroxide is represented by $MII^y(OH)_y \cdot wH_2O$, where MI and MII respectively represent one or more cationic species other than hydrogen, x and y represent average valence states of MI and MII, respectively, and w represents a stoichiometric amount of hydrated water.

194. The mixture of claim 187 wherein said hydride is represented by MI^xH_x and said hydroxide is represented by $MII^y(OH)_y$, where MI and MII respectively represent said one or more cationic species other than hydrogen, and x and y represent average valence states of MI and MII, respectively.

195. A power device comprising:

a fuel cell that uses hydrogen as fuel;

a storage unit containing a hydrogen storage material having a hydrogenated state and a dehydrogenated state, wherein said storage material releases hydrogen used as fuel in said fuel cell, wherein said hydrogenated state of said storage material comprises a hydroxide having a cationic species other than hydrogen and a hydride; and

a filler passage associated with said storage unit for supplying hydrogen to said dehydrogenated storage material in said storage unit.

196. The power device according to claim 195 wherein said dehydrogenated state comprises an oxide.

197. The power device according to claim 195 wherein a hydrogen supply source delivers hydrogen at a temperature and pressure above ambient conditions to said storage material via said filler passage.

198. The power device according to claim 195 wherein when said hydrogen storage material is dehydrogenated, said hydrogen provided to the power device regenerates said storage material from said dehydrogenated state to a regenerated hydrogenated state.

199. The power device according to claim 195 wherein said storage unit is capable of being removed from the power device to regenerate said storage material from a dehydrogenated state to a regenerated hydrogenated state.